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FOR THE

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PRELIMINARY STATEMENT

The chairman of the Committee on Public Works of the House of Representatives was invited on July 20, 1959, to send a delegation of members to attend the International Road Federation meeting at Nice, France, from October 4, to October 6, 1959. They were to participate in a general discussion with representatives of various countries on the general situation with respect to highways throughout the world and in relation to the overall highway program in the United States.

A special subcommittee of the Committee on Public Works attended this meeting and in addition took the opportunity to confer with officials of the respective Ministries of Public Works in Italy, France, England, and Ireland on local highway problems within their various countries and matters of particular interest to the subcommittee, including navigation, flood control, and hydroelectric power development. This report is a brief résumé of the information gained through these various meetings by the members of the subcommittee.

Over the past few years a great portion of the mutual security aid that has been expended and is being expended in the various countries of the world has been devoted to public work construction. The committee believes that highway development and water resource development is of tremendous importance not only to this Nation but to all countries of the world and that the problems that exist in the United States and in the countries visited by the subcommittee are interrelated. This report attempts to sketch briefly the progress that has been brought about in road work and water resources among some of the European countries, the importance of this work and the need for its continued development.

The major portion of the report is concerned with the highway program; there is, in addition, information covering water resources and power program development in those nations visited by the subcommittee.

HIGHWAY DEVELOPMENT

The acceleration of highway programs throughout the free world during the last few years has been startling and the ocmmittee noted that as much as highway construction has increased in the United States it has increased to an even greater extent in other parts of the world. For example, during the period between 1955 and 1958, highway expenditures in the United States increased almost 40 percent. The increase in expenditures in European countries, however, amounted to almost 100 percent. These increases apply to construction on the national level, on the State or provincial level, and on the urban or metropolitan level.

To indicate the magnitude of highway construction throughout the free world, the total expenditure in 1958, including the United States, amounted to slightly more than $17 billion of which approximately $10 billion was spent in the United States.

The free world increased its highway expenditures by 8.3 percent in 1959, pushing total spending to a new record of $18.6 billion for construction, maintenance, and administration.

It was the 12th consecutive year that a new record was set.

The United States (Hawaii and Alaska included) led all countries in expenditures during the year, raising its spending 10 percent to $10.96 billion. Canada was second with $1.19 billion and West Germany third with $960 million.

All regions of the world except South America increased their expenditures over 1958, according to the estimated spending figures of 144 countries and territories around the world. Asia led with a 17.3 percent rise, followed by North and Central America (10.4), Africa (9.5), *Oceania* (5.7), and Europe (1.0). South America's spending dropped 21 percent.

Forecasts are that 1960 expenditures will increase 7½ percent over 1959, reaching a total of $20 billion. U.S. spending is expected to rise 5 percent to $11.5 billion, with spending in other areas increasing by a combined 11 percent to $8.5 billion. If the increased rate of highway construction continues generally along the same lines, it is apparent that the gap between the $7 billion expenditure in 1958 for the free world countries, excluding the United States, and the $10 billion expenditure in the United States would be rapidly closed, and that in about 5 years expenditures in the countries other than the United States will equal or exceed those in the United States. By about 1965 the total expenditures in the free world, including the United States, will amount to approximately the cost of the entire U.S. interstate highway program, or something in excess of $40 billion.

There are a number of reasons for this rapid growth in highway construction in recent times. The increasing use of the automobile in the United States has been paralleled to some extent in other countries, although in these other countries certain economic factors, such as the higher cost of motor fuel, taxes, and general economic conditions, have tended to retard the use of automobiles to some extent. Also, in these other countries the common use of bicycles and motor-driven two-wheeled vehicles, which has fitted into the standard of living, and the lesser distances to be traveled are factors which have made the transition to automobiles not subject to as much pressure as in the United States.

Another important factor in highway development throughout the world has been the growing realization that this type of communication can open up new areas and provide the means of transporting the products of agriculture and mineral resources for much longer distances than have previously been possible economically.

Finally, throughout the world, as in the United States, champions of well-planned highways have arisen from both governmental and nongovernmental groups. They have done much to coordinate and assist in the exchange of technologies, planning, and the general dissemination of facts concerning the value of better highways. In this connection the subcommittee feels that the International Road Federation has been in the forefront of those responsible for organizing

well-planned highway programs throughout the world. For example, the IRF has affiliated associations working for good roads in more than 65 countries. These organizations are composed of civic, governmental, and professional leaders who are concerned with promoting good highway programs in their respective countries. The United States has done much to facilitate this program throughout the world and a great deal of credit is due to the work of the U.S. Bureau of Public Roads and American consulting engineers and contractors who have carried their know-how into the far corners of the world and who have welcomed foreign engineers and students to this country for intensive training in highway engineering.

As an example of the coordinated educational work which is being done among the nations the subcommittee was pleased to learn that, since the International Road Federation program began in 1949, 215 engineers from 60 countries have studied graduate engineering abroad. At the present time 42 highway engineers from 29 countries and territories have reported for classes and are studying advanced highway engineering under the International Road Federation's fellowship program. These engineers are enrolled at five universities in the United States and two in Great Britain. In the United States students are attending Northwestern, Ohio State, Illinois, Purdue, and the Massachusetts Institute of Technology. In Great Britain they are attending Durham and Birmingham Universities. It is interesting to note the countries from which these students come. Six are from Colombia, three are from Vietnam, two each are from Australia, Ceylon, Honduras, Japan, Nigeria, and Turkey, and there is one student from each of the following countries: Bolivia, Canada, British Guiana, Cuba, Denmark, Ecuador, El Salvador, France, Germany, Greece, Korea, Mexico, Nicaragua, Paraguay, Peru, Poland, Portugal, South Africa, Spain, Tanganyika, and Thailand.

Highway safety.—Because of the highway safety program in the United States and the need to reduce the large number of annual casualties, the subcommittee was interested in learning the figures on similar Statistics in other countries. The subcommittee was particularly interested in this important program because of the fact that the Committee on Public Works is, to a large extent, responsible for the overall development of the highway program and related factors throughout the United States. House Document 93 of the 86th Congress, 1st session, which contained a report from the Secretary of Commerce to the Congress, pointed out the vital position of the Federal role in highway safety and stressed the following:

> Motor-vehicle traffic accidents now rank among the leading causes of death in the United States, but a historical review showa significant advances in traffic survey in recent years. The alltime high of 39,969 highway deaths in 1941 has not been exceeded since, in spite of a doubling of the miles driven since that year. The chief improvement in the traffic-death situation has occurred in urban places, where deaths have dropped by a third, almost entirely in the pedestrian class. Rural traffic deaths have increased, principally as a result of noncollision and other single vehicle accidents.
>
> It is concluded that the steady gains in highway safety are the product of many efforts, public and private, expended

on a broad front in a balanced program. More extensive safety education, driver training and improvement, better vehicles, advances in highway and traffic engineering, more effective enforcement, both in traffic supervision and in the courts, wider application of results of improved traffic accident analyses, greater uniformity in traffic laws and ordinances, increased public consciousness of the importance of highway safety, stronger support of official responsibilities in highway safety, and perhaps even a basically safer driver have all operated to produce the gains that have been made.

Although it was found that many features of the highway program throughout the world bore amazing resemblances to the same features and problems faced by the United States, this was not true in all cases, particularly with respect to traffic accident and fatality statistics. According to reports of the National Saftey Council in the United States, the traffic deaths increased 5 percent in the first 6 months of 1959 compared with the same period for 1958. This might be expected because of the larger number of vehicles in operation and the increase in vehicle-miles traveled. In other countries, however, the increasing use of automobiles and the additions to the road network have had widely different results. For example, in Italy, even though the number of automobiles and the vehicle mileage have increased, traffic fatilities have remained at about the same level. The subcommittee noted that traffic congestion is so severe in some areas, particularly in the vicinty of Rome and immediately to the west, that automobile speeds are relatively low in comparison with the customary American speeds. This may be an explanation of the fact that fatal injuries have not increased to the extent that vehicle mileage has. The superhighway program which is now being constructed in Italy, including the "Highway of the Sun," which is mentioned elsewhere in this report, will ease congestion on existing roads. It will be interesting to see what effect, if any, there will be on the fatality rate because of the faster driving speeds which will be allowed.

Throughways

As evidenced in the United States by the authorization of the Interstate Highway System, there has been a growing realization through the world of the need for through highways as distinguished from local networks. These highways include those which may connect distant parts of the same country or which may be international in nature and connect a number of countries. Some of these are described in the following paragraphs.

Pan American Highway.—One of the most famous international highways in the Western Hemisphere is the Pan American Highway which will extend from Alaska to Buenos Aires and connect almost all of the capitals of the Americas. The Inter-American Highway, which is sometimes confused with the Pan American Highway, is actually a part of the latter and is the section which extends from the Mexican-Guatemalan border to Panama City. When a few relatively short sections are completed, this highway will be passable from the southern border of Mexico to Panama. Together with the highways through Mexico, it will then be possible to travel by car from the United States to Costa Rica.

With respect to the South American portion of the Pan American Highway, it is fairly well completed from Colombia on through the rest of South America. The missing link in this great highway of the Western Hemisphere is the section between Panama and Colombia, known as the Darien section, which, because of topography and inaccessibility, poses some of the worst problems in the whole network. Planning is continuing, however, on this section and it is hoped that eventually these problems will be solved. The committee's complete and detailed report on the Pan American Highway is continued in Committee Print No. 22, 86th Congress.

European Highway

With respect to Europe, there is an international road system which provides modern transportation between the major capitals and cities in the various countries. The subcommittee took the opportunity, where available, to inspect the highways, not only on the Continent but in Ireland and England as well, particularly in connection with new work and new concepts. While the subcommittee did not see all of the highways mentioned in this report, information concerning the roads in those European countries which were not visited was obtained from delegates attending the road conference in Nice.

In Switzerland a new expressway is now under construction between Geneva and Lausanne which appeared to meet modern standards. In addition Switzerland's tremendous development in both domestic and international road traffic has resulted in a new road plan sponsored by the Government. Under the new program a national road network 1,037 miles in length has been authorized to be constructed. Most of this construction it is anticipated will take place between 1960 and 1970. The cost of this program is roughly $675.9 million. Further, Switzerland's Parliament has approved plans for the long-discussed 3.5-mile tunnel under the Grand St. Bernard Pass, and work has started. The $1.5 million project is scheduled for completion some time in 1961.

In London a new expressway between the city and the airport is similar to various highways in the metropolitan areas of the United States. In London there has recently been completed and dedicated an overpass which removed a very congested bottleneck along this expressway.

One of the most interesting projects mentioned at the International Road Federation meeting was a study, then underway but since completed, on the feasibility and desirability of a tunnel under the English Channel. Another interesting project is a highway tunnel under Mont Blanc. These are described briefly later in this report. Other European projects in the planning stage include a proposed arterial road system for the city of Oslo, Norway, with a four-lane divided freeway running along the waterfront. This road will connect with a valley east of the city where most of Oslo's industry is or will be located. In Austria there are two projects of special interest to highway engineers and planners. The first is the Duernstein Tunnel near Vienna which has been opened to traffic. It is the longest tunnel in Austria, being 1,550 feet in length. An interesting feature is the use of automatic counting devices at each entrance. These control the volume of ventilation in accordance with the volume of

traffic. The second is located on the Brenner Expressway, the Europe Bridge. This has a total length of 2,350 feet and a maximum height above the valley of 590 feet. There are five steel spans with a maximum pier height of 460 feet. The bridge was designed for a wind pressure of 125 miles an hour.

Great Britain

When Great Britain's current 4-year road program ends in 1962, the Government is expected to be spending at least $168 million a year on new road construction. In 1959 more than $112 million was spent on new roads in Britain. In 1960 more than $140 million will be spent and in 1961 at least $182 million will go into new highways.

Greece

Greece inaugurated a 5-year road program to improve its main highways. At present, the country's central highways, while carefully maintained, are so winding and narrow that average speed of buses is 25 to 30 miles per hour. Under the road program, Greece is building a network on which the average speed is expected to be 50 to 60 miles per hour. This net will cost $173 million by the end of 1963.

Germany

Germany started a 12-year plan which is designed to accommodate all traffic for the next 20 years. On the Government level it calls for expenditure of $5.376 billion, of which $4.056 billion will be spent for first-class roads and $1.32 billion for new expressways.

First step in the plan is a 4-year program now underway. This calls for expenditure of $1.92 billion by the end of 1962. In the record 1959 budget, $408 million was appropriated by the Government under this plan. By 1971, a total of 1,240 miles of new expressways will be constructed and 7,626 miles of existing Federal roads will be rebuilt or relocated.

Portugal

Portugal's national roads are being built under a 15-year plan authorized in 1955. Under this plan, the nation will spend $214 million for national highways. The program calls for construction of 1,116 miles of new roads. Main projects now underway in the national program are two expressways totaling 20 miles. Built in Lisbon and Oporto they will be finished in 1960 and will cost $7.6 million.

Municipal highways are being built under a 6-year economic development plan approved in 1958. By 1964 this plan calls for the expenditure of $2.6 billion for all economic development projects in Portugal. These 6 years form the first third of an 18-year program for municipal roads calling for total expenditures of $89 million. At the end of 18 years, 3,906 miles of new roads will have been built and 3,720 miles of highways will have been reconstructed and modernized. This municipal road system will provide access to all towns with more than 150 inhabitants.

Sweden, Norway, and Denmark

A new international highway servicing both Norway and Sweden has been officially opened. This 22-mile mountain highway runs through Storlien, Sweden, and provides a connection between road networks that formerly ended at the highway's two terminal cities, Enafors, Sweden, and Koppera, Norway.

The new road replaces an old mountain connection to the north that is closed to automobile traffic in winter. It provides a more direct route from the Gulf of Bothnia coast of Sweden to Trondheim Fjord in Norway.

Preparations for construction of the $46.6 million "birdflight route" between West Germany and Denmark were completed. The new highway, between Roedby and Fehmarn, will replace a ferry across the Baltic Sea between Gedser, Denmark, and Grossenbrode, Germany. The ferry trip alone now takes 3 hours. On the new route the entire trip between Roedby and Fehmarn will take about an hour. Scheduled for completion in the fall of 1962, the road will shorten the distance between Copenhagen and Hamburg by almost 85 miles. It will form the main traffic line between Norway-Sweden and central Europe.

Another freeway under construction will connect Stockholm with the new Swedish airport, Stockholm-Arlanda. About 25 miles long, this highway is scheduled for completion in 1963.

A modern bridge system between the Swedish mainland and three of the country's most important islands is now under construction and will be completed in 1960. Total length of the bridges is over 3,000 feet.

Poland, Hungary, and U.S.S.R.

From what the committee could ascertain, highway development in this area is being pushed as rapidly as possible. The brief information that is available covers Poland, Hungary, and the U.S.S.R.

Poland is carrying on an intensive highway reconstruction program. Since 1954, it has built 5,846 miles of new paved highways, reconstructed 2,250 miles of state road, constructed 274,000 feet of steel and concrete bridges, and 318,000 feet of temporary wooden bridges. A 15-year plan (1961-75) has been prepared for the modernization of all state roads and the construction of new routes which will increase the mileage in Poland's network by 20 percent.

Hungary has announced 943 miles of its roads will be modernized in the next 2 years. Eighty bridges were built by the end of 1959.

U.S.S.R. says it is going to build 46,000 miles of new roads of all types by 1965. The longest single project would be the 625-mile Moscow-Stalingrad highway.

As previously mentioned there are two projects that are of special interest and for this reason brief comments on their plans and present status follow.

English Channel tunnel

A study of possible plans for tunnels under or bridges over the English Channel has been recently completed. The channel tunnel study group has investigated the possibility of tunnels and bridges both for rail and highway traffic. The idea of the channel tunnel is not new and has been under discussion for many years. The present study, which has been made by a group representing British, French, and U.S. interests, is considered to be the most thorough ever undertaken.

It has been estimated that the highway tunnel would cost between $400 million and $500 million. In comparison the proposed bridge would cost slightly more than $500 million. A combined railway and

highway tunnel would cost about $560 million. The group found that the most favorable plan would be the construction of railway tunnels. Three tunnels would actually be constructed—two for railway traffic and one between the two for service needs. The cost of this plan is estimated at $360 million, of which $224 million would be for construction, $56 million for interest and other charges, and $80 million for installations, terminal facilities, and rolling stock.

Not only would this plan be the least expensive of the several studied but it would provide, according to computations, receipts and revenues in excess of those which would be available from either the highway or the combined highway-rail plans. In addition, it appears that the proposed plan could be privately financed, with some assistance from the nationalized British and French railway systems. The other plans would not have this advantage.

With respect to timing, it is estimated that it may take about a year before the two Governments involved can reach a final decision and, if favorable, it would probably take another year for engineering design and planning prior to construction. The construction period would be about 5 years.

The location of the tunnels would be across the Strait of Dover between Calais, France, and the vicinity of Folkestone, England. The portion under the water would be 23 miles long and the combined length of the underground approaches would be 9 miles. It is planned that special trains will be built to carry automobiles. The capacity would provide for 1,800 vehicles and 4,200 passengers an hour in each direction. The travel time between London and Paris, now about 8 hours, would be cut in half.

Mont Blanc Automobile Tunnel

Because of the unusual nature of the project the subcommittee was particularly interested in the automobile tunnel under Mont Blanc. An agreement signed by Italy and France in 1953 provided for its construction. It will run between the French valley of the Arne and the Italian valley of Dora Balta. It will be approximately 7 miles long and will be the longest automobile tunnel in the world. The entrance on the Italian side will be at elevation 4,570 feet. The tunnel will then rise slightly to its highest point and exit on the French side at elevation 4,100 feet. The roadway will be 23 feet wide and the side height of the tunnel will be 15 feet. The grade will be 2.6 percent on the French side and 0.6 percent on the Italian side. Ventilation will be provided by a separate tunnel built to cope with the 120° temperatures expected to be encountered. It will form a permanent road connection between the two countries. Construction is now underway and if it proceeds on schedule indications are that it will be open in 1962. It will provide the only winter avenue through the Alps between Geneva and Brenner Passes which are 400 miles apart.

French highways

In addition to the information gained at the International Road Federation meeting the subcommittee was fortunate enough to have the opportunity to discuss highways and waterways in Paris with M. Claude Abraham, Deputy Director, Ponts and Chasses, and M. Adrian Nicol, Deputy Director, International Affairs. Similar to

Italy, as discussed elsewhere in this report, France has the same general classification of highways, national departmental, and regional. The total length of the national network is 50,000 miles, the departmental 170,000, and the regional, which includes rural, 230,000. Almost all of this total of 450,000 miles of road is paved. The number of motor vehicles in France, not including 2-wheel vehicles, is approximately 6 million, or about 1 to 8 persons. This includes trucks which amount to about 1,600,000 of the total. In addition, there are about 5 million motorcycles or bicycles with motors.

In the national highway system the total amount spent annually for new roads amounts to 1.5 percent of the national budget or approximately $50 million. This compares with the U.S. percentage of about 3.2 to 3.9 percent for Federal expenditures of $2.5 to $3.2 billion. In addition, another $50 million in France is spent on maintenance. The financing is accomplished through a special fund. Theoretically 18 percent of the gas tax goes into the fund, but in actual practice, as of last year, only 6 percent went in.

As in other countries taxes are extremely high although not so high as in Italy. The cost of gas per American gallon is 70 cents, of which 50 cents amounts to tax.

The overall planning of French highways has followed the general trend in other countries which has recognized the close relationship between highway growth and the economic development of the country. A national program known as the Commissariat du Plan has been proposed which would include construction of ,500 miles of expressways of which 10 percent would be urban highways and the remainder interurban. The cities which would gain relief from the construction of the urban highways are the major ones in France such as Paris, Lyon, Marseilles, and Bordeaux. With respect to the interurban highways, they will give Paris fast connections with the west coast of France, Lyon with the south coast, and Lille with the north. Other expressways will link major industrial centers.

The program is in its infancy since only about 150 miles of expressways have been constructed, most of this in urban areas. In 1960 the so-called Paris-Southern Highway will be completed, which is part of a complex of roads designed for the Paris area to rejuvenate several old sections of the city. As in the United States the use of bypasses is common. Some have been already completed in the Rhone Valley, and most will be incorporated into the freeway which will lead to Paris, through Lyon, to Marseilles on the Paris-Southern Expressway. One of the several major projects which have been completed or are now underway is the Mont Blanc Tunnel, described earlier in this report.

A number of new bridges have been built across several of the rivers, of which the most spectacular is the one recently opened near LeHavre, and which crosses the Seine River at Tancarville. This is the longest suspension bridge in Europe and is 3,150 feet long between piers and 4,600 feet long counting the approaches to the suspended portion.

The committee was impressed by the fact that in improving its international and national road network the French are rebuilding a total of 7,000 bridges.

Italian highways

One of the most interesting features of the subcommittee's trip was the information gained in Italy on Italian highways. Meetings were

held in Rome with officials of the Ministry of Public Works. These meetings gave the subcommittee a good insight concerning some of the public works problems faced by the Italian Government.

Although many of the problems in connection with highways are similar to those which are faced in the United States, the history of Italian roads goes back for thousands of years. Two thousand years ago Rome had a network of finely engineered and well built roads. Many of these are still in existence and even bear the same names, such as the Appian Way, for example. Instead of chariots and marching legions these roads now carry high speed, heavy density, modern bus and truck traffic in ever-increasing numbers.

Despite the excellence of these roads in the past, both from an engineering and durability point of view, Italy today is faced with a growing highway inadequacy. Her spectacular postwar recovery and prosperity has brought with it a sharp increase in car ownership and a virtual revolution in freight haulage. In 1939 the railroads accounted for 70 percent of the goods moved by land and the highways for the remaining 30 percent. Today the figures have been reversed. However, as in many other countries highway construction has not kept pace with rising demands being made upon it.

In the immediate postwar period the principal problem, of course, was to rehabilitate the existing roads, bridges and tunnels. With that well underway Italy is starting the effort now necessary to modernize her highway system, and is taking a long stride toward its solution with the construction of hundreds of miles of expressways. These are being built or are in the planning stage. The improvement of primary highways is quite essential to a country like Italy because of her many mountain ranges. Two land highways which force through traffic to travel up and down grades, around and between mountain ranges, are an economic liability which Italy can no longer afford.

At the same time that an effort is being made to improve the top-level highways, a smaller and quieter effort is being made to improve the overall standard of Italy's lesser roads. This refers not so much to their construction, which is standardized and is of high quality, but to their administration. In Italy there is a curious mixture in this area of dependence and independence on the part of smaller governmental entities in their relations with the national Government. While largely dependent on the national Government for highway funds they are likewise largely independent as to the expenditures of such funds. As a result there is a movement toward a gradual assumption of more and more direct responsibility by the national Government for road construction and maintenance through the device of reclassifying roads as State highways.

There is an organization in Italy for the construction of highways which is important to understand. This is ANAS which is the abbreviation for an organization called the Azienda Nazionale Autonoma delle Strada Statali. This is an organization of the state, the provincial, and the communal governments organized in 1928 with the responsibility for Italian national and international trunkroads. It is by far the most important Italian governmental agency, national, provincial, or local, in the highway sector. Its budget is normally attached to that of the Ministry of Public Works and the Minister of that department is the nominal chairman of the agency.

In comparison to the duties of the U.S. Bureau of Public Roads, it is interesting to note the tasks assigned to ANAS which include:

(1) The maintenance and construction of State highways and highway signals.

(2) The drafting of rules and regulations for the protection of highways, vehicle circulation, and traffic discipline.

(3) The classification of roads (State, provincial, or communal).

(4) The letting of contracts with third parties for the construction of highways.

The objective of Italian legislation in the field of highway contruction and maintenance, past and present, is to have the local administrations, provincial and communal provide for their own needs through local taxation. Under an act of 1949 provision was made for the Ministry of Public Works to pay for a period of 35 years an annual subsidy varying from 2 to 5 percent of the construction costs of provincial and communal roads required to link communes or parts of communes with the existing national road network. Since its passage a total of approximately 7 million dollars has been disbursed to the provinces and to the communes.

More recently a policy designed to promote a vast program of private expressway construction has been adopted. Under the 1955 law the state may provide up to 40 percent of expressway construction costs, the balance being supplied by the highway contractor who then operates the expressway on a toll basis as a private enterprise for 30 years. At the end of that time the road becomes the property of the state.

Taxes are obtained from several automotive sources in Italy. One principal source is the circulation tax levied directly on each automobile, truck, and bus based on its use and on the horsepower of the vehicle calculated according to its piston displacement. Because of the fact that private pleasure vehicles the rates rise sharply as piston displacements become higher, a premium has naturally been put on the development and use of small motors of high efficiency capable of operating at near maximum capacities. Several factors besides horsepower, however, are taken into account in setting tax rates on motor vehicles in Italy. Motor buses and trucks, for example, do not carry proportionately nearly as heavy rates as do private autos. At one extreme a small car such as an 8 horsepower Fiat is taxed at approximately $1.50 per horsepower or a total of approximately $12. At the other extreme the rate per horsepower on a 36-horsepower Chevrolet increases to $4 per horsepower or a total of $144. These are annual figures. This explains, of course, why American cars lack mass appeal in Italy. On the other hand, it is interesting to note that taxicabs and hired cars carry only half the regular passanger car rate with a further slight reduction granted for those 20 years old or older. These half rate features explain why hired car companies are conspicuous among the few able to operate larger cars in Italy. These taxes which are called circulation taxes are similar to the license fees levied by the individual States in the United States. Unlike the gasoline tax which goes directly into the general fund all the money collected under the circulation tax is used directly for road construction and maintenance.

Gasoline is heavily taxed in Italy, making gasoline there the highest priced on the Continent. For example, the total tax including pro-

duction tax, general sales tax, and port charges amount to 55 cents per American gallon. The subcommittee notes with interest, in view of recent discussions in the Congress concerning gas tax, that in Italy it is a recurring complaint that gasoline taxes, as heavy as they are, are not set aside even in part for highway construction, maintenance, and improvement but rather are deposited in the general fund. The actual cost of gasoline in Italy, exclusive of taxes, is 22 cents per gallon, which added to the tax makes a total cost at the gas station of 77 cents per gallon.

By far the greatest source of money for highway construction, improvement, and maintenance is the national treasury by way of the budget of the Ministry of Public Works. For this reason it is in the last analysis the Italian Parliament which, in voting the funds, determines to a great degree Italian road policy. While there is a certain degree of autonomy in the provinces and communes these are in reality dependent on the central government for any sizable fund. State roads built and maintained by the central government are provided for in the budget for the Ministry of Public Works. Similarly a portion of the money for the operation of provincial roads is provided for in the same budget. However, one large and automatic source of revenue for the provinces for highway use comes from the vehicle circulation tax described before. Two-thirds of this tax is allocated to the provinces. One-third of the tax collected, that is one-half of the money allocated, is divided among the provinces according to their geographical size and one-third is prorated according to the mileage of provincial needs.

In theory such a division strikes a nice balance between the large developed areas and the smaller but more economically advances provinces, providing funds for new road construction for the former and money for the proper maintenance of an already developed and possible extensive road network for the latter. The fact is, however, that the funds so allocated are not sufficient and the provinces have become more and more dependent on the national treasury for their highway development money.

The proposed development of Italian highways is a part of the so-called Vanoni plan which is briefly a series of guidelines for Italy's economic development designed to bring about full employment by 1964. Recent highway construction in Italy shows rapid advancement toward a fully developed integral highway system.

A new 56.4 mile stretch of Italy's Highway of the Sun has been opened to traffic. This brings total completed milage on the toll road to 125 miles.

Two of the road's major works are completed. A large bridge over the Po River was opened, connecting two formerly isolated parts of the country to the road system. A "road gallery" under the Appenine Mountains was also completed, giving the Highway of the Sun access to Toscane Province.

The highway portion of this plan calls for investment of approximately $1,744 million in road construction and improvement. Something less than one-half of this amount has been invested to date. In round figures about one-third of this amount is for new expressways, one-third for the widening of existing state roads, one-quarter for the improvement or alinement of provincial roads and the balance for miscellaneous work.

The Italian highway system is divided into expressways, national roads, provincial roads, and communal roads. In addition to these, as in the United States, there are a considerable number of land reclamation roads, forest roads, and camping roads.

At the apex of the system are the expressways, or super highways. These may be state owned and operated with tolls, or toll free, or they may be privately operated. These are the fast traffic, limited access, through roads incorporating maximum curve radia with minimum grades together with greater than usual widths and often dual lanes. They are located principally in the north of Italy and are relatively few in number. Compared with throughways in the United States they tend to run for only short distances. Their value is, however, being increasingly recognized. There are nine existing expressways which have a total of only 300 miles. Those which are in the planning or construction stage will cover about 600 miles.

The national or state highways, 198 in number, follow in many cases the ancient Roman tracings. They were originally built for defense and until the proclamation of the Italian Republic they had an essentially military character. They link the principal Italian cities with one another and with the important ports. Crossing the Alps they join Italy's highway network with the major international highways of her neighbors. The total length of these roads is approximately 15,000 miles and amounts to 14 percent of all the Italian roads.

With respect to provincial roads, their specific purpose is to link together the capitals of each province, the communes, and the important divisions of them. They also connect provincial capitals with the nearest airports, railway stations, and ports. Their mileage is approximately 30,000 and they are an important part of the nation's transportation network. As stated before, there is an increasing tendency, because of the financial burden they represent, for the National Government to take over the administration of these roads.

The last classification, the communal roads, are those which join the communes to their communal fractions, railway stations, airports, sea, river, or lake ports or localities with less than 20,000 inhabitants. Lastly they link neighboring communes of the same or bordering provinces. Streets within the confines of cities are not classified as communal road unless they connect a communal road traversing the city. This category of roads has a total mileage of something in excess of 60,000 miles.

U.S. highways

To supplement this report on highways it might be of interest to give the present status of highway construction in the United States (as of February 29, 1960).

Construction contracts have been completed on 5,958 miles of the National System of Interstate and Defense Highways at a cost of $2.46 billion, since July 1, 1956. As of February 29, 1960, construction was underway on 4,580 miles at an estimated cost of $2.93 billion. Included in the program were 4,860 bridges completed and 4,704 underway. In addition, $2.29 billion has been authorized or spent for preliminary engineering work and acquisition of right-of-way since July 1, 1956.

In the continuing program of Federal assistance for the improvement of the Federal-aid primary and secondary highway systems and thier

urban extensions (the A–B–C program), work has been completed since July 1, 1956, on 84,339 miles, including 14,609 bridges, at a cost of $5.22 billion. As of February 29, 1960, construction contracts were underway under the A–B–C program on 20,372 miles and 4,560 bridges, at an estimated cost of $2.34 billion.

NAVIGATION

Port of London

Because of its concern with the rivers and harbors of the United States and their development for navigation and flood control, the subcommittee took the opportunity to confer with officials of the Port of London Authority. This was of particular interest because of the development of harbors along the coast of the United States by port authorities such as the Port of New York Authority, the Baltimore Port Authority, etc.

As with highways and other projects inspected by the subcommittee some differences were noted between the United States and British type of development and some similarities. Perhaps one of the most noticeable differences was the relatively great age of British and other European developments in comparison to the relatively younger age of the American ports. Ports like New York and Boston date back to the beginnings of the country, whereas ports like London date back to pre-Roman times. It was the Thames which, flanked by marshlands and dense forests, gave security in early times to small ships using its navigable channel. Through this channel they could proceed upstream until the first ford was reached near the present site of London Bridge. There in the "Pool" safe anchorage was found where cargoes could be loaded and unloaded alongside the river banks or by means of smaller craft. As a result, London became an established trading center. Over the years improvements were made, such as those used to reinforce the river banks to facilitate cargo loading, and these improvements became the forerunners of the hundreds of wharves which now form an essential part of the port.

These facilities remained reasonably satisfactory until congestion became so great during the 16th and 17th centuries that the Government found it almost impossible to collect revenues. Attempts were made to solve the problems which arose from the congestion and the difficulty of collecting revenue in a number of ways but it was not until construction of the West India docks was authorized by Parliament that the present system of numerous docks was inaugurated. The West India docks were opened on the 27th of August, 1802. The main pattern of London's dock systems appeared as other docks followed, and the pattern was completed by the construction of Tilbury docks in 1886. In the beginning the various docks were in private hands but early in the 20th century there arose a demand for better coordination, the elimination of wasteful competition, and greater efficiency. A Royal Commission was set up which resulted in 1908 in the bill which authorized the Port of London Authority. This covers the entire reach of the tidal Thames which amounts to 69 miles. The ownership of the docks, which were by then coordinated into five different systems, passed into the control of a new type of corporation established by statute and practically independent of the National Government. This was the body known as the Port of London Authority

The constitution of this authority is relatively complex. The board consists of appointed and elected members representing all the interests in the port. There are 10 appointed members nominated by the Admiralty, the Ministry of Transport, the London County Council, the Corporation of the City of London, and the Corporation of Trinity House. Of the remaining 18 members, 8 are elected by shipowners, and 8 by merchants; 1 represents the public wharf owners and 1 the owners of river craft. The total membership of the Authority may, therefore, be as much as 30.

Financially the port authority is only concerned with the problem of collecting sufficient revenue to provide for accomodations and services and pay interest on debt. Any excess of revenue over expenditures is available for port improvements or reduction of charges. The total amount authorized by Act of Parliament to be borrowed is approximately $180 million.

One of the interesting features about the port of London is the fact that the authority has to deal with a tidal range on the Thames between 14 and 21 feet and, therefore, the construction of lock entrances has been required at all of the dock systems. The authority has built new lock entrances, modernized old ones, and has installed modern impounding pumping stations to maintain the level of dock water well above that of high water. This is a problem which has not generally been experienced in U.S. ports. However, the subcommittee notes that a similar problem is experienced at New Orleans, not because of tidal range, but because the height of the levees along the Mississippi River necessitated by the unusually high fluctuation between high and low water, which can be as much as 20 feet, has required a ship lock between the river and the inner harbor.

England

The problem of water, including its use and freedom from pollution, the subcommittee discovered, is as great a problem throughout Europe as in the United States. Although the consumption of water in England and Wales is expected to rise by about 23 percent during the period ending in 1965 a Central Advisory Water Committee of the British Government had indicated in a report entitled "The Growing Demand for Water" that the rainfall "is sufficient to insure an adequate supply of water to all parts of the country provided the proper means of conservation and distribution are developed to keep pace with the growing demand." In addition this report emphasized the fact that "a satisfactory situation in the future must rest on the readiness of all concerned to regard water as a valuable commodity and to provide money and materials accordingly."

The committee learned through its visits with members of foreign ministries in other nations that their problems are similar to those existing in Great Britain.

The problem of flood protection is still an important one in a country as old as Great Britain and one where its rivers have to a great extent been fully, built up and developed. An interesting project which is now under consideration by the authorities in England is the proposal for the construction of a movable flood barrier across the Thames in Long Reach, Dartford, to give full protection from the tidal flooding to the heavily built-up areas farther up the tideway.

France

France has a somewhat unusual method of handling harbor improvements. For the large ports the construction of new improvements is undertaken by the Government and by chambers of commerce on a 50–50 basis. These chambers of commerce are different from those in the United States in that they are more in the nature of statutory public organizations. Their functions might be likened to those of drainage, levee, and conservancy districts in this country. For the small ports the Government contribution varies but is less than 50 percent.

Although the subcommittee did not attempt to explore in any detail the field of electric power, it did take advantage of an opportunity while in France to learn something of French power production. The subcommittee considered that this might be of interest because of the responsibilities of the Committee on Public Works in the field of power in the United States. This includes the power features of projects of the Corps of Engineers, which are recommended for authorization by the committee, and also includes the operation of the Tennessee Valley Authority. The information readily available pertains to the predominant electric-power-producing organization known as Electricite de France.

This organization was founded in 1946 and since that time the entire consumption of electricity by France has increased from 24 to 62 billion kilowatt-hours. It has, therefore, been multiplied by more than 250 percent. The targets set by the so-called French modernization plan are 70 billion kiilowatt-hours by 1960–61 and 112 billion kilowatt-hours by 1965–66. In addition to the organization referred to, the demand is met by other companies, including companies which generate their own electricity for industrial purposes.

According to information obtained by the subcommittee, the use of hydroelectric power has been constantly increasing. New developments are distributed over practically all rivers where feasible. These include both storage reservoirs at the heads of various valleys and run-of-river plants. The annual generation from plants now in operation amount to some 5 billion kilowatt-hours.

Considerable progress also appears to have been made in the field of thermal power generation. Improved techniques and greater standardization have been credited by the French as factors which have resulted in more economical power stations. Plants recently completed, and most of those in the course of construction, have a capacity of 125,000 kilowatts. Some of these are new installations and some have been or are being built to replace obsolete plants. It is understood that projects now in the course of construction involve a total of approximately 2 million kilowatts.

In the field of nuclear power generation a small start is being made. As a beginning, small units have been installed to recover the energy from air cooling nuclear reactors, but there are now in the course of construction two reactors intended solely for the production of electricity.

Equal strides have been made in the construction of new transmission networks. It is understood that increasing use is being made of high voltage transmission. Double lines of 225 kilovolts have been constructed with the intent of transforming them later into single

380-kilovolt lines. A line of this latter voltage was put into operation in the vicinity of Paris in 1958.

Additional detailed information on the electric power program of France, including pictures and descriptions of individual installations, have been collected and are available in the files of the committee.

In connection with its brief study of power projects in France, the subcommittee noted with interest a proposed project somewhat similar to one which has been under consideration a great number of years in the United States. The project in the United States to which the French project bears a similar resemblance is the Passamaquoddy tidal power project in Maine. The French Government is considering a tidal power project for the estuary of the Rance River. The chief details of the project are as follows:

The average tide at the mouth of the Rance River, Britanny, France, is 38 feet. At midtide, the flow is 15,000 cubic meters (approximately 530,000 cubic feet) per second. This is a volume approximately 300 times that of the Genissiat Dam on the Rhone River. It has been estimated that the annual power production of a tidal plant at this spot can be up to 700 million kilowatt-hours.

Electricite de France is about to start construction of a powerplant to utilize the energy of the tides in the northern part of an estuary above Saint-Malo, Saint-Servan, and Dinard, on a line joining the right bank at La Brantais and the left bank at La Brebis.

When the dam has been built, as now planned, the sea will flow up the estuary, the water level, at high tide, will rise by about 18 feet above mean sea level. The water gates of the dam will then be shut. After a wait of approximately 3 hours, and when the tide receds, the water in the estuary will be admitted into the turbines. Power will thus be generated until the retained water again reaches sea level. The drop of the water through the turbines will amount to approximately 175,000 cubic feet per second. As presently planned the powerplant will generate annually approximately 550,000 kilowatt-hours of electricity.

Initial installation will consist of 26 14,000-horsepower turbines, linked to a 3-phased alternator of 8,000 kilowatts capacity. Cost of the project was estimated in November 1954 to be 20 billion francs (about $57 million).

While the committee was in France the final phase of the preparation for the opening of the Serre Poncon Dam was underway. This dam which is Western Europe's largest dam and the first to be made of earth is now on full-scale operation. Its creation promises bright economic prospects for southeastern France. Its water is supplied by the backing up of the Durance and Ubaye Rivers to form a greenish-blue lake that is expected to rival in scenic beauty and expanse the Lake of Annecy in the department of Haute-Savoie not far from Geneva.

The French have completed a powerplant and locks at Vogelgrun and are now beginning a similar facility downstream at Markolsheim. This is part of an overall project being developed in eastern France parallel to the German border known as France's Grand Alsace Canal project which it is hoped will develop power and improved navigation on the upper Rhine River.

This project envisions a major navigation canal paralleling the Rhine on the French side and equipped with eight powerplants to

develop the 350-foot head in the 70-mile reach of the river between the Swiss border city of Basle and Strasbourg, France. About 30 miles of the canal and four powerplants are now in service. As in other similar cases, the project is under the direction of Electricite de France.

The Grande Alsace Canal is approximately the same size as the Suez Canal, and thus a waterway of major proportions. Its water depth is 31 feet and, with bank slopes of 3:1, it has widths of 450 feet at the water surface and 263 feet at the bottom. About a half-mile above each power station and lock installation the canal divides into two branches, which merge again below. The branch used by shipping is 375 feet wide at the waterline and 187 feet at the bottom.

There are two locks side by side at each location. Those at Kembs, the first installation completed, are 82 feet wide and 330 and 600 feet long. Elsewhere both lock chambers are made 600 feet long, but one is 75 feet wide, while the other has a width of only 40 feet. The smaller lock can be emptied or filled in 11 minutes; for the larger the lockage time is 18 minutes.

The water velocity in the canal is 4 feet per second compared to as much as 10 feet per second in the river, which offers a considerable cost saving to shipping. About 5 million tons of products are moved between Basle and Strasbourg each year.

Revised plan for developing Rhine River for power and navigation foregoes a continous Grand Alsace Canal for a series of short canal reaches

The four power stations so far built are essentially alike in design and roughly of comparable capacities. Kembs, the first completed (1932), contains six 28,000-kilowatt generating units and operates under a gross head of 54 feet. Ottmarsheim, finished in 1952, and Fessenheim, in 1956, and under approximately the same head as at Kembs, are equipped with four 40,000-kilowatt and four 44,000-kilowatt units respectively. Vogelgrun, just completed, is equipped with four 40,000-kilowatt units which operate under a gross head of 44 feet.

The powerplants are equipped with Kaplan turbines. They discharge over gated spillways into a stilling basin fitted with energy-dissipated concrete pyramids so as to keep the canal water as tranquil as possible for navigation.

All of these stations are on the continuous portion of the Grand Alsace Canal. Markolsheim, which is now under construction, will be the first to be built in accordance with the new plan where canal reaches alternate with river reaches. Its principal element of difference will be the diversion dam in the river. This will be a gated structure with five openings 100 feet wide and 36 feet high separated by 23-foot-wide piers.

The canal, which this diversion dam serves is of practically the same dimensions as the Grand Alsace Canal and about 4½ miles long. For the first 1½ miles it is 450 feet wide, then widens to 835 feet (to provide a waiting harbor for shipping) before it divides into two branches, one leading to the locks, the other to the powerplant. Below these facilities, the canal runs for another 1½ miles to empty its waters back into the Rhine.

The Markolsheim powerplant will contain four 40,000-kilowatt units, and the locks of the facility will be of the same type and dimensions as those at the completed projects upstream. It is contemplated that Markolsheim will be finished in 1962, and that three similar projects downstream will then be undertaken successively, so that the entire upper Rhine project can be finished by about 1967. At that time it is estimated that the eight powerplants will produce some 7 billion kilowatt-hours per year to be fed into the French power net.

Each of the projects so far completed has been a construction job of major proportions. Ottmarsheim, for example, required 26 million cubic yards of excavation, Fessenheim 32 million cubic yards, and Vogelgrun 17 million cubic yards. Because less canal length will be required for Markolsheim and the remaining projects downstream, excavation will be less, but will still average about 15 million cubic yards for each project.

Each power station and lock layout requires nearly 1 million cubic yards of concrete. In addition, all canal banks and bottom above the ground-water table are lined with concrete in the form of precast, vacuum-processed slabs, which adds a considerable concrete yardage to each job.

Construction problems encountered on the different projects have been those common to most large earthmoving and excavation operations. Electric shovels of 3- to 5-cubic-yard size and draglines with 12-cubic-yard buckets have been used to load 27-cubic-yard trucks. As much as 1.3 million cubic yards of earth has been moved in a single month.

The deep powerplant excavations have also posed dewatering problems. At Fessenheim, for example, where the hole was 600 feet long, 300 feet wide, and 80 feet deep, bentonite and silicate of soda were injected on the sides and below the bottom to assure watertightness prior to excavation. The injected layers were from 15 to 30 feet thick. About 42,000 tons of injecting material was required, placed by two pumping plants working continuously for 7 months.

Italy

In its discussions with the Ministry of Public Works in Rome, the committee delved into the question of dam construction in Italy. It was interested to learn that dam construction has a lengthy and old background in Italy and that several 15th and 16th century masonry structures are still in service, but it is in the last few decades that the most varied and extensive achievements have been made throughout Italy. This is the result of the fact that exploitation of the country's scarce hydraulic resources, both for agricultural and industrial purposes, requires many large reservoirs to store the water from streams with very irregular flow-rates.

Over 300 dams are in operation in Italy. This figure refers to structures of more than 33 feet and a storage volume of more than 80 acre-feet. Actually the majority are much larger. Approximately 70 percent of the dams are higher than 80 feet and 14 of them are more than 330 feet high. These figures are those that were available as of September 1958. Since that period about 40 more dams have been under construction, 8 of them higher than 300 feet.

Italian dams are built mostly for hydroelectric purposes; many combine this aim with irrigation and other purposes, while about 10 percent serve irrigation only.

Italy along with all the other nations of the world continuously faces the problems of floods and the havoc and devastation that arise in their wake. An article from the London Times of December 15, 1959, explains this problem quite clearly, as follows:

> Signor Colombo, Minister for Industry and Commerce, has just completed a tour of the areas in Lucania that were devastated by the recent floods. Informed local opinion has been interpreting the disaster as final proof of the Government's mistaken approach for 10 years or more to the problem of developing this intractable region, which is one of the most backward of the Italian south. The Minister, being Lucania-born and enjoying great political influence among the voters of the region, would naturally take it on himself to promise prompt measures of recuperation and try to restore public confidence in the wisdom of the Government's expensive schemes.
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> He did both. Events of a quite exceptional character such as these floods should not, he said, be allowed to cast doubt on the validity of the fine work of improvement undertaken by the democratic state. That work must continue, with an emphasis on the projects that would reestablish peace of mind in the peasant families and confidence in the prospect of economic progress for the whole zone.
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> Signor Colombo suggested that a more efficient network of drainage canals should be provided and riverbanks strengthened. He visited families still waiting to be able to return to their homes, and assured them of his solidarity. Two things had already been pointed out to him, if indirectly: the first, that promises of prompt and effective help must be kept, and secondly, as students of the south had for years been telling the Government, that development and land reform should have begun high in the mountains, not in the plains.
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> One of the main areas developed by the Government's projects in Lucania is the comparatively fertile plain on the Ionian coast around Metaponto and Policoro. That was also one of the main areas afflicted by flooding. Four of the five rivers running into this plain—the Basento, the Cavone, the Agri, and the Sinni—burst their banks. The fifth, the Bradano, is controlled by a dam.
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> Floods of this kind and on this scale are uncommon in Lucania. In the neighboring region of Calabria they occur every year; riverbeds, which have been dry throughout the summer, are transformed into torrents which inundate the neighborhood, carrying away the houses and—in some ways more serious—the soil. It is doubtful whether anyone knows the full extent of this annual damage, though the toll in terms of human misery is substantial. Certainly, next to nothing is done to prevent its constant recurrence. The unusual case this year of much the same happening on a

serious scale in Lucania has drawn attention to the entire problem of regular inundations in the south.

The lesson that Signor Colombo did not draw from the sight of flooded farms in the plain of Metaponto is that good works must begin on the heights. Most of this region, and most of Calabria, is mountainous. The mountains are cut by stony riverbeds, dry in summer, overfull in winter. The force with which the water rushes down the steep slopes, as well as the sheer volume, is destructive.

The solution would inevitably be slow and unspectacular, unlikely to show results for years—planting new forests where old ones have been cut down; building dams and strengthening riverbanks; changing watercourses. All these measures have been advocated for years, as the first stage, by some groups of experts.

Ireland

Although Ireland is basically an agricultural country it, too, is attempting to move ahead with full speed in development of its rivers and streams for hydroelectric power purposes. At the time the committee was in Europe the $12,870,000 Lee hydroelectric development project was officially opened. It represents 7 years' work and planning. In addition to the direct advantage accruing from the two power stations, the Irish Government believes it will confer several subsidiary benefits on the surrounding areas. An example of this may be seen in the new and raised roads extending over a total length of 11 miles and in the three new major bridges built across the reservoir to replace those flooded in the course of construction.

The Lee salmon, too, are protected by specially designed fish passes, and their future is doubly assured by the installation of a hatchery at one of the stations.

The Lee development is the fifth scheme of its kind to be carried out in this country, and its completion brings the number of E.S.B. power-generating stations to nine.

Because to these stations, the face of the countryside has in many ways been altered, and their effect is obvious in every home, where electricity now provides an easy comfort undreamt of 50 years ago. For the days of the oil lamps have well-nigh passed, and across the bare Irish hillsides, the sentinels of rural electrfiication push confidently forward with their gifts of light and heat.

The Lee project is a major one, which involved the construction of dams at both Inniscarra and Carrigadromid. The two lakes created as a consequence are approximately equal and have a storage capacity of about 5 percent of the river's annual flow and a total area of 3,500 acres. The power stations built at each dam between them equal 27,000 kilowatts, one-third of the capacity of Ardnacrusha.

At Inniscarra, the station houses two generating sets, one of 15,000 kilowatts and the other of 4,000 kilowatts. The latter, which in case of emergency, can be operated without an outside electricity supply, was installed to give sufficient downriver flow to meet the requirement of water supply plant in Cork City. It also acts, however, as a house set to both the Lee hydrostations and the 60,000-kilowatt steam station in Cork City.

The dam at Inniscarra is 800 feet long and 140 feet high with an 8-foot-wide walkway along its crest. It is divided into 19 blocks with an efficient water seal between each and, at the top of the dam, a spillway promotes the smooth discharge of water. A deep basin below riverbed level prevents erosion of the riverbed and banks by destroying the energy of the discharge, two banks—one on the upstream side of the dam at reservoir level and the other at tailrace level on the downstream side—provide a fish pass similar in principle to the Liffey pass at Leixlip.

For the conditions prevailing this type of fish pass is considered to be cheaper and simpler than the conventional stepped pools on the Erne.

Water is admitted to the upper chamber from the reservoir and flows down the connecting shaft inside the body of the dam to the tailrace from which it escapes through a sluice gate. The salmon enter the pass through this sluice and are trapped there when the gate closes. The inflow of water, however, continues until it rises to reservoir level and the fish are enabled to swim up the shaft into the top chamber.

From here they can escape to the reservoir through an upper sluice while fry and fish that have spawned can also descend from the reservoir to tailrace en route to the sea. The whole operation is automatically controlled and when sufficient time has elapsed for the fish to enter the reservoir, the lower sluice opens and the cycle starts again.

The Inniscarra power station is situated immediately downstream of the dam intake blocks and gives easy access to the public road. Fifty-four feet wide by 112 feet long, its lowest foundation level is 60 feet below the original ground surface and the steel spiral inlets to the turbines are concreted into the foundations.

There are two main floors in the station, the turbine floor and the generating floor. Upstream of the station, supported partly by it and partly by the dam, a low building accommodates the control room and 10KV switchgear. A two-story building to the north of the station contains workshops, stores, and offices. The Carrigadrohid power station is remotely controlled from Inniscarra and its dam, 350 feet long and 70 feet high, consists of nine blocks, varying from 30 to 61 feet in length. Here, however, there is no spillway; but instead because of the configuration of the ground and, particularly, to suit river diversion during construction, ground sluices have been used. There are three of these—any two capable of coping with the maximum estimated flood—the gates are operated by remote control from Inniscarra.

Although modified to suit the individual requirements of the site, the fish pass at Carrigadrohid is basically similar to that at Inniscarra. The power station itself houses a single 8,600-kilowatt turbine and is designed as an integral part of the dam structure, the whole being heavily reinforced.

There is only one floor level (containing a 60-ton electric crane) at Carrigadrohid, and the switchgear and control room adjoining the main building is situated over the lower chamber of the fish pass. A separate building close to the station houses offices and stores.

At both Carrigadrohid and Inniscarra, the alternators generate at 10,000 volts, which is stepped up to 110,000 volts and transmitted by an overhead line to the main transmission system at Kilbarry. The turbines in both stations are of the vertical Kaplan type with the blades of the rotating runners automatically adjusted so that high

efficiency is maintained even when the turbines are producing less than full output.

The spiral casings leading the water to the turbine runners are made of steel embedded in concrete at Inniscarra, but at Carrigadrohid where pressure is less, the spiral entry has been made entirely of concrete.

The entrance in the dam to each turbine is provided with a trash rack and with steel intake gates, which serve to isolate the turbine for inspection and overhaul. The gates drop automatically in an emergency while, on the downstream side, draft tube gates enable the turbine area below tailrace level to be pumped out when necessary. Each station is equipped with traveling overhead cranes.

The main transformers 2MVA and 5MVA and H.T. switchgear are situated in a compound downstream of the Inniscarra station, while at Carrigadrohid the main transformer (12 MVA) is situated on a platform beside the station building.

The bridges and road works required by the Lee project involved the shifting of about 300,000 tons of earth and rock and the placing of some 10,000 tons of concrete.

The three bridges which cross the reservoirs are the Rooves, the Lee, and the Bealaghaglashire.

Made of reinforced concrete and designed as portals with piers at 66- and 44-foot centers, they have a free span supported by rocker and roller bearings on cantilevered brackets between each pair of portals.

The fish hatchery at Carrigadrohid is at present capable of producing about 400,000 fry each season, but it is intended to increase its capacity so that 1¼ million eggs can be incubated.

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